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ABSTRACT

Pre-selection criteria were developed to obtain a profile of student nurses who would complete a community college nursing program, and student nurses who would leave the program prior to completion. The battery consisted of tests and questionnaires based upon cognitive, personality/attitude, vocational preference, and socioeconomic status domains. A student sample was randomly chosen from applicants obtaining acceptable scores on the General Aptitude Test battery and the Nelson-Denny Reading Score test. These candidates were administered the George Washington University Nursing Test, the Strong-Campbell Interest Invertory, the Coopersmith Self-Esteem Inventory, the Cattell 16-PF Personality Test, a measure of attitudes towards the nursing profession and academic success, and a questionnaire covering demographic, community, and adult education background. Using 121 variables and data from 1975 test scores and subsequent records of program completion, a simple correlation of each variable with student persistence/non-persistence was obtained. The correlations were used to select a subset of variables which were significantly correlated with the criterion variable. Discriminant analysis was found to be a valid way to obtain weights for a prediction equation, and its use is recommended for counselors and administrators involved in nursing school admissions. (Author/JAC)

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# MULTIPLE CRITERIA DEVELOPMENT FOR THE SELECTION OF COMMUNITY COLLEGE NURSING PROGRAM STUDENTS

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I. INTRODUCTION - BACKGROUND TO THE STUDY

II. PREDICTION OF STUDENT NURSE PERSISTERS/ NON-PERSISTERS

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I. INTRODUCTION - BACKGROUND

During the program development stage (prior to September, 1975) the Douglas College Nursing Program Administrators recognized that pre-selection procedures must be devised to reduce potential student dropout rates. Besides the normal institutional requirements which demand that students attain specific levels on cognitive tests, that they have a pre-defined type of secondary school education, and that they attend counselling interviews, it became clear through an intensive nursing research literature review that one other selection method ought to be attempted--to create, through a battery of pre-selection tests and questionnaires, a "profile" of the so-called student nurse persister (completes full program) and the non-persister (leaves program prior to completion).

If such a profile could be developed and validated for the Douglas College Nursing Program, then student nurse applicants could sit for selected tests and questionnaires and, based on score output, be classified into two segments--the potential persister and the potential non-persister.

Nursing literature provided a wealth of information on the above consideration. Four areas or test domains stood out as very important when attempting to predict the persister/non-persister: standardized cognitive, personality/attitude, and vocational preference tests, as well as a socio-economic questionnaire.

Using the above nursing research framework a two-tier test procedure was developed. All program applicants were given the General Aptitude Test Battery. In order for the applicant to be considered further

a minimum score had to have been obtained on four sub-scores: general learning ability; numerical ability; clerical perception, and; motor co-ordination.

Assuming the applicant obtained a minimum acceptable score she/he was placed into an "entrance group pool" and randomly chosen to become a nursing student. The individual took one further pre-entrance cognitive test: the Nelson-Denny Reading Score. Based on this score the individual was either required or not required to take a remedial English course before attending their first semester (usually prior to August).

Tier two tests and questionnaires were then given to prospective students who were randomly chosen from the "pool". These latter tests were given to the individual before attending the September classes.

The cognitive tests, besides including the previous two, added one other--The George Washington University Nursing Test. The vocational preference test utilized the Strong-Campbell Interest Inventory, and the attitude/personality tests included two categories: (1) the first related to feelings about the nursing profession as well as their own expectations about success in the Douglas College program and beyond, to their on-the-job work; (2) the second included two standardized personality tests--the Coopersmith's Self-Esteem Inventory (SEI) and the Cattell 16-PF Personality Test. One other questionnaire was given. It covered the individual's demographic, community interest and adult education background.

In total, 121 variables within the four test domains were developed. Using this information the following two sections will describe how the authors

have proceeded since data were first collected (prior to September, 1975). This includes the development of two potential predictive tools along with their expected usefulness for counsellors, administrators and teachers.

## II. PREDICTION OF STUDENT NURSE PERSISTERS/NON-PERSISTERS

The basic problem:

We have information (for example a test score) on a person which we would like to use to predict whether that person will be a persister or alternatively a non-persister.

A simple solution:

If we have information on others who have taken the same test and if we know whether they were persisters or non-persisters, we can use this past information to predict which group (persister or non-persister) a person is likely to fall into. A simple procedure would be:

a. Compare the person's test score with the average value obtained on that test by persisters and the average value obtained by non-persisters.

b. If his score is closer to the average for persisters than the average for non-persisters, classify him as a potential persister.

c. If his score is closer to the average for non-persisters than the average for persisters, classify him as a potential non-persister.

Some considerations that arise when attempting to make predictions:

1) We must assume (perhaps erroneously) that whatever relationship a score on the test had with tendency to persist will continue without changing much over time. That is, we assume that the future will be "like" the past. This is partly a philosophical problem which is inherent in all scientific endeavors which attempt to formulate physical laws from past observations.

2) The relationship between the test score and group membership may be inconsistent. That is, there may have been some whose scores were closer to the average score for persisters than to the average for non-persisters, yet who actually were non-persisters. Conversely, there may have been some whose scores were closer to the average score for non-persisters than to the average for persisters, yet who actually were persisters. Such persons, if we were to try to predict their group membership using their test scores, would be classified incorrectly. For example, we might find the following kind of situation:

| | Predicted | |
|---|---|---|
| Actual: | Persister | Non-persister |
| Persister | 27 | 7 |
| Non-Persister | 13 | 32 |

The above table indicates that 27 individuals were correctly classified as persisters and that 32 were correctly classified as non-persisters. Seven persisters were incorrectly classified as non-persisters, while 13 non-persisters were incorrectly classified as persisters.

Obviously, the ideal predictor would have a perfectly consistent relationship with persistence and would result in no misclassifications. However, there are very few such perfect relationships in the real world. Hence, there will nearly always be some misclassifications. The percentage of correct classifications may be taken as a measure of how consistent our predictions are. In our example above we found:

$$\% \text{ of correct classifications} = 100 \times \frac{27+32}{27+7+13+32} = 74.7\%$$

To know if that figure is really a good one we must compare it with what we would expect to get on the average if we assigned individuals to the two groups in relative proportions (predicted persisters vs. non-persisters) by some random method completely unrelated to persistence. Probability theory suggests that:

$$\text{expected \% of correct predictions by chance} = 100 \times \left[\left(\frac{27+13}{79}\right)\left(\frac{27+7}{79}\right) + \left(\frac{7+32}{79}\right)\left(\frac{13+32}{79}\right)\right]$$

$$= 100 \times (.218 + .281) = 49.9\%$$

Thus, we may conclude that our prediction is better than chance by an amount equal to

$$100 \times \frac{74.7 - 49.9}{49.9} = 49.7\% \text{ better than chance.}$$

Using the Chi Square statistic we can obtain the probability of getting results that good or better by chance.

$$\text{Chi square} = \frac{79\left[\left|(27)(32)-(7)(13)\right| - \frac{79}{2}\right]^2}{(27+7)(13+32)(27+13)(7+32)} = 17.8^*$$

Looking the chi square figure up in a table we would find that the probability is less than one in a thousand (i.e., $p < .001$). Anything less than five in a hundred (i.e., $p < .05$) can ordinarily be considered acceptable. Our result above would be considered acceptable. If our predictor variable (the test score) can do no better than random assignment then we must reject it as a predictor.

Improving the prediction:

Suppose that we have two different kinds of tests we would like to use as predictors. How can we combine the information each contains so as to obtain a single predictor, y, which is better than either one used separately. We could simply compute the average and use that as a predictor just as we would use a single test score:

$$y = \frac{X_1 + X_2}{2} = \frac{1}{2}X_1 + \frac{1}{2}X_2 \qquad \{\text{equal weighting}\}$$

where $X_1$ = score on test 1,
$X_2$ = score on test 2,
$y$ = average score;

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*Yates correction for continuity is used here since the degree of freedom for a 2x2 table is equal to 1.

However, test 1 may have a range of 0 to 100 while test 2 has a range of 0 to 50--the score on test one might be weighted too heavily. We could alleviate that problem by converting $X_1$ and $X_2$ to standardized scores:

$$\text{standard score } X_i' = \frac{X_i - (\text{mean of } X_i)}{\text{standard deviation of } X_i}$$

Yet several problems still remain. If test score $X_2$ is inversely related to persistence (i.e., score is low when persistence is high, and vice versa), we wouldn't want to add it to $X_1$, rather, we would want to subtract it:

$$y = \frac{1}{2}X_1' - \frac{1}{2}X_2' \qquad \{\text{equal but reverse weighting}\}$$

Note that our predictor, y, can be considered to be the weighted sum of two variables:

$y = k_1X_1' + k_2X_2'$, where $k_1$ and $k_2$ are the weights.

When the weighting is equal, $k_1 = k_2$ (If there are m predictor variables, $k_i = \frac{1}{m}$). If a variable is inversely related to what we are trying to predict, the sign of $k_i$ is negative.

What if $X_1$ is twice as good a predictor as $X_2$--perhaps the weight for $X_1$ should be twice as large as the weight for $X_2$:

$$y = \frac{2}{3}X_1' + \frac{1}{3}X_2' \qquad \{\text{weighted average}\}$$

Another consideration is correlated predictors. If two predictors are highly correlated they both measure nearly the same thing and thus together should be weighted less relative to the other predictors. A predictor adds little additional information if it is

highly correlated with another predictor (consider the extreme case where two equally weighted predictors are perfectly correlated--one can be completely removed and the weight of the other doubled without affecting the value of y at all).

Discriminant analysis:

Clearly, when two or more predictors are involved, the task of finding the weights which would give the best prediction can become extremely involved. Discriminant analysis is a convenient mathematical tool for obtaining a set of weights ($k_1, k_2, \ldots k_m$) which may be used for combining the information in a number of predictor variables, simultaneously taking into account all the considerations discussed above.* Using the weights obtained from the analysis one may calculate a single value y for any individual as follows:

$$y = k_1X'_1 + k_2X'_2 + \ldots k_mX'_m, \qquad \{\text{discriminant score}\}$$

which can be compared with the average y value for persisters and with the average y value for non-persisters to obtain a classification decision.

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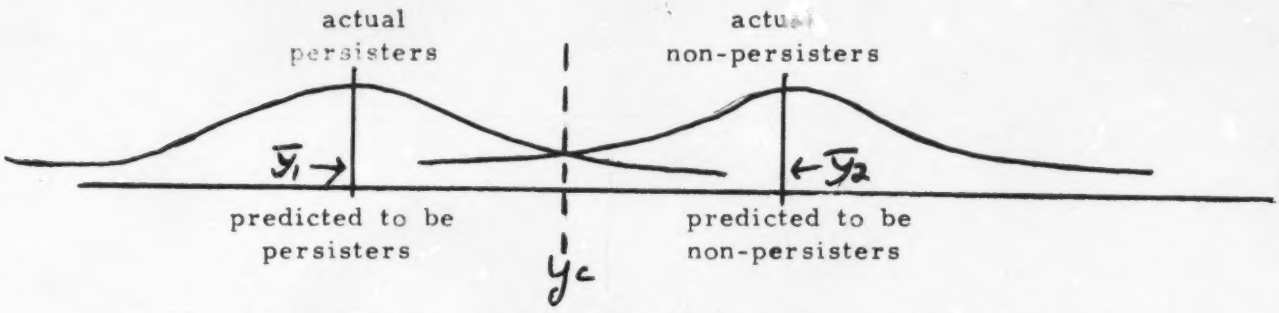
*For those familiar with matrix notation, one model (among a number of variations) is:

$(X^TX)k = (m_1-m_2)$
$k = (X^TX)^{-1}(m_1-m_2)$
$\bar{y}_1 = km_1$
$\bar{y}_2 = km_2$

where: X is the raw data matrix,
$m_i$ is the vector of means for group i,
k is the vector of weights,
$\bar{y}_i$ is the average y for group i (i.e., the centroid for group i).

If one calculates a y value for each individual in each group, the following kind of distribution will likely be obtained:




$\bar{y}_1$ here is the average y value for the persister group; $\bar{y}_2$ is the average y value for the non-persister group, and $y_c$ is a value midway between $\bar{y}_1$ and $\bar{y}_2$ used as the cutoff value for predicting membership in one group or the other. The shaded areas represent the individuals whose group membership has been incorrectly predicted using y. Discriminant analysis attempts to find a set of weights ($k_1$, $k_2$, $k_3$, ... $k_m$) which will result in y-values yielding distributions for the two groups, which will be as far apart as possible relative to the spread of y values within each of the groups, thus minimizing the amount of overlap and accordingly reducing the likelihood of misclassifications.

Results of using discriminant analysis to obtain the weights for our prediction equation:

Using the data from our 1975 intake of 79 students (scores on a large number of tests and questionnaires covering cognitive performance, attitude, personality traits, vocational preference, socio-economic background, and biographical information), a simple correlation of each variable with persistence/non-persistence was obtained. *

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*The Statistical Package for the Social Sciences (SPSS) developed at the University of Chicago under the sponsorship of the National Opinion Research Council was used on the computer at Simon Fraser University to perform this analysis. (1)

For persisters this variable was coded 0, for non-persisters it was coded 1. The correlations were then used to select from our original set of 122 variables a subset of variables that are each significantly correlated with our criterion variable (2 tail $p \leq .05$). The variables selected by this pre-screening procedure are presented in Table I. To eliminate redundant (highly intercorrelated) variables and to obtain weights for the selected variables a stepwise discriminant analysis* was performed on the variables selected by the above pre-screening procedure. The variables selected by the stepwise discriminant analysis and the weights obtained are presented in Table II.

Using the procedure illustrated in Table III each individual in the 1975 intake was predicted to be a potential persister or non-persister based on the person's discriminant score. The predictions were then compared with the known group membership as follows:

| | Predicted | |
|---|---|---|
| Actual: | Persister | Non-persister |
| Persister | 27 | 7 |
| Non-Persister | 8 | 37 |

81% of the individuals were correctly predicted. By chance we would expect an average of only 51% correct classifications. For this table the chi square calculated to be 27.4 indicates that by chance we could obtain 81% or better correct classifications fewer than one in a thousand times. Hence we may conclude that the discriminant score is likely to be a useful measure for predicting persistence/non-persistence. Just how useful can be determined by using the same weights obtained from the 1975 intake data on a new and

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*The Statistical Package for the Social Sciences (SPSS) developed at the University of Chicago under the sponsorship of the National Opinion Research Council was used on the computer at Simon Fraser University to perform this analysis. (1)

different set of data. If the discriminant score effectively predicts persisters and non-persisters in the new sample, we will strengthen our confidence in its utility as a predictor.

Accordingly, a discriminant score for each individual in the 1976 intake of students was calculated and used to predict whether the person would be a persister or non-persister. The predictions were then compared with the known group membership to date* as follows:

| | Predicted | |
|---|---|---|
| Actual: | Persister | Non-persister |
| Persister | 21 | 32 |
| Non-Persister | 7 | 28 |

This indicates that we have correctly classified 56% of the individuals so far. By chance we would expect an average of only 46% correct classifications. For this table the chi square calculated to be 2.89 indicates that by chance we could obtain 56% or better correct classifications fewer than nine in a hundred times. This is not a strongly conclusive result, but the fact that we have correctly predicted 80% (28 out of 35) of the non-persisters to date and that there are a number of individuals in the program who may yet withdraw, suggests that we are on the right track.

Figure III illustrates the strength of the relationship between the discriminant score and percentage of non-persisters. For example, in the 1976 intake group 55% (14 out of 25) of those who had discriminant scores greater than 1 have turned out to be non-persisters, while of those who had discriminant scores less than -1, none (0 out of 5) have turned out to have been non-persisters. The relationship is even more dramatic for the 1975 intake group, but this is to

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*The students in this intake will not be through until --------, hence our data is not yet complete.

be expected since the discriminant function weights were calculated on that group's data and hence exploit as much as possible the interrelationships of the variables involved, including some that inevitably will turn out to be unique for that group. Figures I and II illustrate the overall distribution of discriminant scores. An upward shift in the distribution appeared to take place for the 1976 intake sample for as yet undetermined reasons. This resulted in a larger proportion of individuals predicted to be non-persisters.

Conclusions:

The Discriminant score appears to have a considerable potential utility as a basis for predicting or pre-classifying individuals as potential persisters or non-persisters. The simple procedure for calculating the discriminant score makes this kind of prediction available to counsellors and administrators who may make use of the information provided therein to improve the chance potential non-persisters have of completing the program or perhaps to screen out prior to entry those who have a very poor likelihood of completing.

Table I.

Potential predictor variables selected using correlations with persistence/non-persistence (coded 0 and 1 respectively) where the significance level of the correlation was .05 or less (2 tail test) in the data from the 1975 intake group:

| Code Name | Variable | Correlation with Persistence/ Non-Persistence | Significance Level |
|---|---|---|---|
| SCRNS | Strong Campbell Reg. Nurse Scale (standardized score)* | -.27 | .016 |
| GWUNTR | George Washington University Nursing Test (raw score)* | -.32 | .004 |
| NDR | Nelson Denny (raw score)* | -.27 | .015 |
| EMPUN | Student was employed before entering program (1=yes, 2=no)* | .24 | .039 |
| MILES | Miles travelled to school one way* | -.25 | .033 |
| AWI | Adolph Whaley Index* | -.23 | .042 |
| C16RL | Cattel 16 PF Trusting-Suspicious (raw score) | .25 | .024 |
| C16RN | Cattel 16 PF Forthright-Astute (raw score) | .23 | .045 |

* Variables also selected by the stepwise discriminant analysis performed on the 8 variables above using the 1975 intake data.

Table II.

Predictor variables and their weights obtained by the stepwise discriminant analysis of the 1975 intake data using only those variables having significant correlations with persistence/non-persistence (see Table I.):

| Code Name | | Standardized Weight* | Unstandardized Weight** |
|---|---|---|---|
| SCRNS | Strong Campbell Reg. Nurse Scale (standardized score) | -.371 | -.377 |
| GWUNTR | George Washington University Nursing Test (raw score) | -.202 | -.00946 |
| NDR | Nelson Denny (raw score) | -.366 | -.0336 |
| EMPUN | Student was employed before entering program (1=yes, 2=no) | .368 | .822 |
| MILES | Miles travelled to school one way | -.489 | -.0595 |
| AWI | Adolph Whalley Index | -.475 | -.128 |
| | Constant | --- | 13.112 |

* May be interpreted as providing an indication of the relative importance of each variable as a predictor--used as a weight when all data is standardized.

** The discriminant score, y, may be calculated using unstandardized data and these weights as in the following formula:

$$y = -.377*SCRNS-.00946*GWUNTR-.0336*NDR+.822*EMPUN-.0595*MILES -.128*AWI+13.112$$

TABLE III

AN EXAMPLE OF HOW TO MAKE A PREDICTION FOR AN INDIVIDUAL GIVEN THE PERSON'S SCORES ON THE PREDICTOR VARIABLES

| Variable | Individual's Score On Variable | | Unstandarized Weight | | Product of Score and Weight |
|---|---|---|---|---|---|
| SCRNS | 5 | x | -.377 | = | -1.885 |
| GWUNTR | 143 | x | -.00946 | = | -1.353 |
| NDR | 44 | x | -.0336 | = | -1.478 |
| EMPUN | 2 | x | .822 | = | 1.644 |
| MILES | 7 | x | -.0595 | = | - .417 |
| AWI | 69.9 | x | -.128 | = | -8.947 |
| Constant | ---- | | ---- | | 13.112 |
| TOTAL (discriminant score y) | | | | = | .676 |

The average y score for persisters was -.627
The average y score for non-persisters was .505

We chose the cutoff value for y to be the midpoint between the average y's for the two groups:

$$\text{cutoff} = \frac{-.627 + .505}{2} = -.062$$

Since the individual's discriminant score is closer to the non-persister extreme (i.e., greater than the cutoff value -.061), we classify the individual as a likely non-persister

TABLE IV

THE PROFILE OF THE PERSISTER VERSUS THE NON-PERSISTER SUGGESTED BY DISCRIMINANT ANALYSIS OF THE 1975 INTAKE STUDENT DATA

| Variable | Average Value For Persisters | Average Value For Non-persisters | p* |
|---|---|---|---|
| Strong-Campbell Registered Nurse Scale(standardized score) | 4.44 | 3.92 | .016 |
| George Washington University Nursing Test(raw score) | 150.3 | 136.7 | .004 |
| Nelson-Denny(raw score) | 44.4 | 38.5 | .015 |
| Student was employed before entering program(1=yes, 2=no) | 1.16 | 1.36 | .032 |
| Miles travelled to school (one-way) | 13.5 | 9.53 | .046 |
| Adolph-Whaley Index | 73.0 | 71.2 | .043 |
| Discriminant Score | -.627 | .505 | .000 |

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*significance level calculated using Student's t-test for the difference between two means (2-tail test, 77 degrees of freedom)

FIGURE I

Distribution of Discriminant (y) Scores Within the 1975 Intake
n = 79

Discriminant Function Weights Were Derived from this Same Set of Data

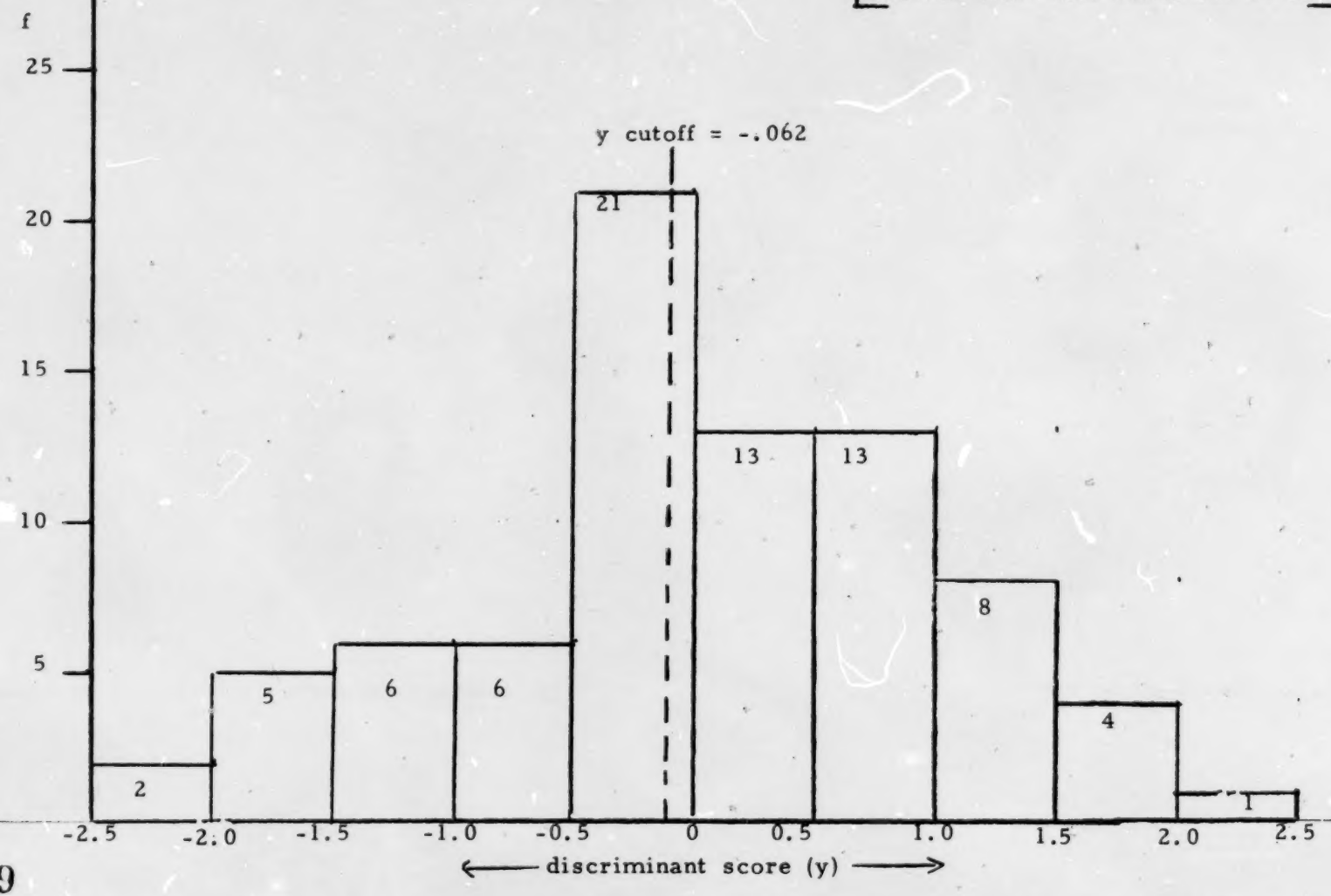


FIGURE III

Percent Non-persisters as Related to Discriminant Score (y)

[Discriminant Function Weights Were Derived from the 1975 Intake Data]

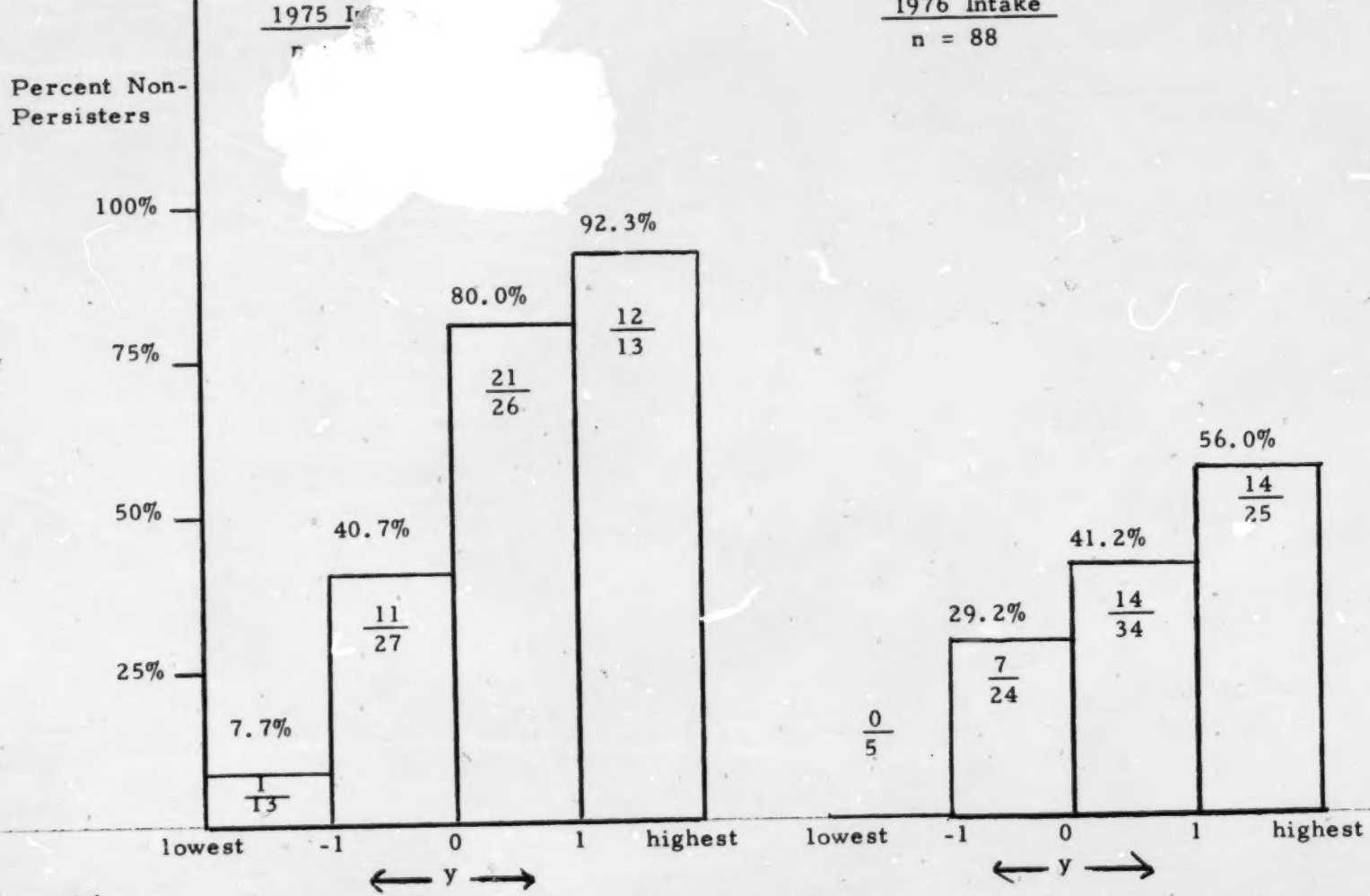
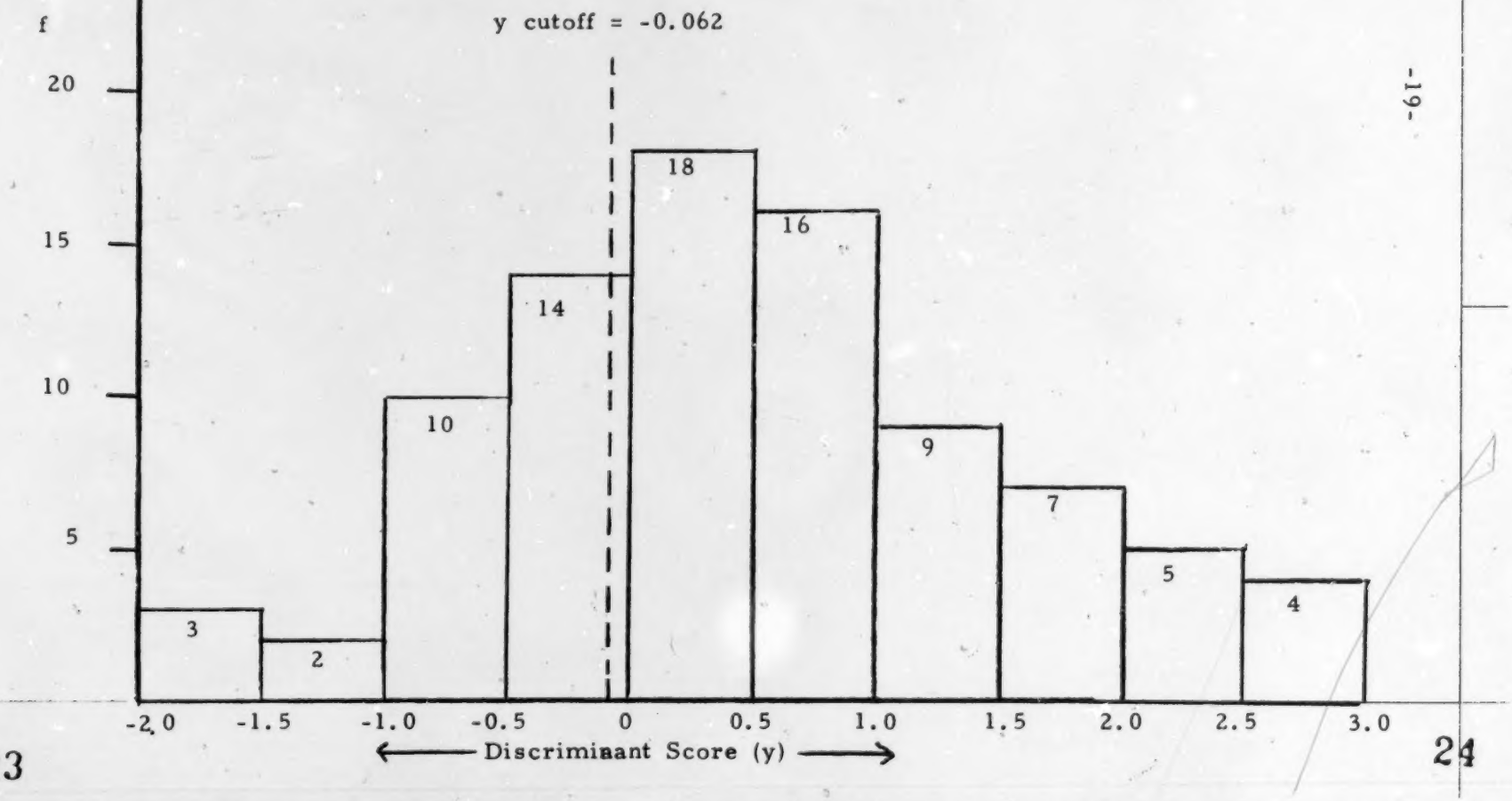


FIGURE II

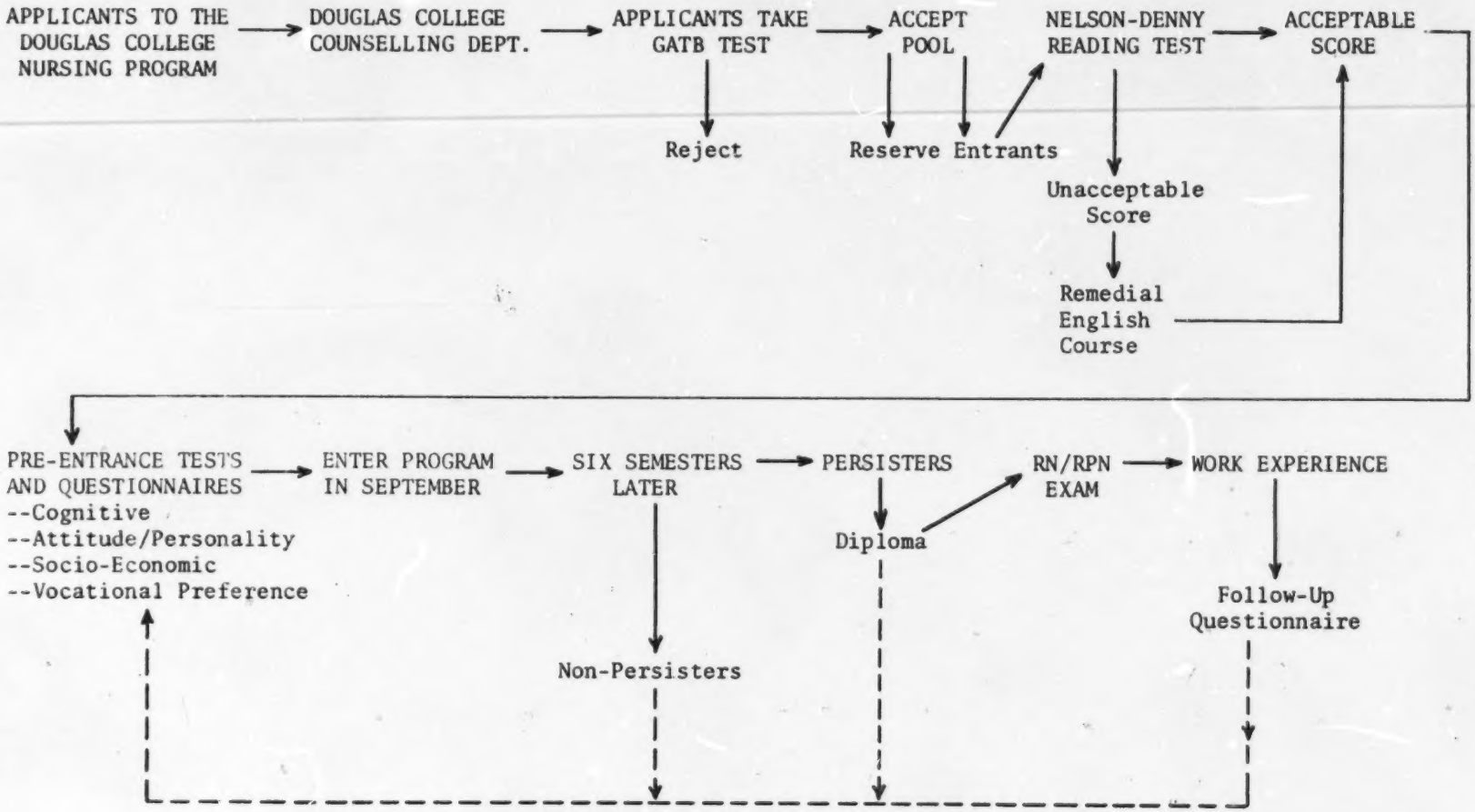
Distribution of Discriminant (y) Scores Within the 1976 Intake

n = 88

[Discriminant Function Weights Were Derived from the 1975 Intake Data]



DOUGLAS COLLEGE SIX-YEAR SELECTION CRITERIA STUDY



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